Industrial mustard crops for biodiesel and biopesticides

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In order for biodiesel to succeed as an U.S. industry and contribute to energy diversity on a significant level, a suitable oil crop needs to be identified and developed. The successful oil crop for biodiesel must be able to avoid the pitfalls of other oil seed crops: limited supply potential and high oil costs. Industrial mustard is a seed crop that can produce low cost oils for biodiesel production and a biopesticide coproduct made from the meal of the mustard seed.

Background

Fuel grade biodiesel can be manufactured from seed oils, animal fats, and recycled cooking greases. These feedstocks can be used individually or blended together to produce biodiesel with specific characteristics. There are an infinite number of technological approaches possible for producing an ASTM quality biodiesel. ASTM standards for biodiesel are feedstock neutral and do not specify or limit the type of technology used to produce biodiesel. ASTM standards define what properties a biodiesel fuel must exhibit for use in a compression ignition engine. Desirable fuel properties can be controlled through feedstock blending, additives, and various types of process technology.

With the advent of a fuel standard, engine manufacturers can develop warrantee positions, and the retail market place can expand. And expand it has. U.S. interest in biodiesel has exploded in the last 18 months. Several factors have contributed to the heightened interest in biodiesel. Feedstock diversity has led to stunning reductions in production cost. Fuel prices for the pure biodiesel (B100) have fallen from $4.50 in 1997 to $1.00/gal in some places today. Sales are projected to expand exponentially this year. Expanding demand is partly the result of new Energy Policy amendments passed by Congress in 1998 that allows blends of biodiesel that exceed 20% in diesel fuel to quality for alternative vehicle incentives. Environmental benefits and low toxicity of the fuel have also led to expanding private and commercial use. The support of the petroleum distribution companies has controlled transportation and infrastructure costs. These firms are currently purchasing, storing and blending biodiesel for end customers, and handling taxation issues as well.

With the expansion in demand, two critical questions are asked: How much biodiesel could be produced in this county? At what price? The answers to these questions are key to determining if biodiesel could play any significant role towards fuel diversity, economic growth and environmental quality. Despite the free fall in production costs, biodiesel feedstock resources are limited. Recycled greases and animal fats produce an inexpensive biodiesel but are limited in supply and by other constraints. Soy oil and other seed oils are used to produce biodiesel at the high end of the supply curve, but expanding these crops will drive down prices in the animal feed markets and automatically limit the supply potential in this key sector. DOE needs a crop that could produce 6-12 billion gallons per year of low cost oil for less than 10 cents per pound. At that level, biodiesel could contribute 10 to 20% of the total diesel requirements of this country for slightly less than $1.00 per gallon. The U.S. DOE mustard project addresses all of these issues and offers a significant potential to meet fuel diversity goals.

The mustard project

A suitable crop for biodiesel must meet the following objectives:

1. Be able to supply 6-12 billion gallons of feedstock oil
2. Raw crushed oil can be produced for 10 cents a pound or less
3. Oil must contain more than 90% monosaturates

4. Oil must be inedible for humans and livestock and possess no high value for industrial use
5. Non oil portion of the crop must possess high market value, in excess of 12 cents per pound
6. Non oil portion of the crop must face expanding market demand
7. Market demand for non oil portion of the crop must be large enough to absorb billions of pounds of material
8. Crop must be suitable for large scale production in the U.S. (not limited to small regions)
9. Crop should be low input and offer significant rotation or other environmental benefits
10. Crop should not be in basic research stage of development, but preferably in a early commercial production stage
11. Suitable production and crushing technology should be available.
12. Crop yields per acre are comparable to commercial crops and offer the potential to expand
13. Oil yield is at least 25% to 40% of the crop product.
14. Crop is profitable to farmers and crushers

The Office of Fuels Development has selected industrial mustard as the promising feedstock crop for biodiesel because it meets all the criteria above. The key development that makes mustard so promising is that the defatted meal (after the oil is removed) can be used as a pesticide without further processing. Through in vitro breeding, the meal can be significantly enhanced, becoming more cost effective and thus, more attractive to pesticide users. Specific varieties show promise for product specialization, so that some types are fungicides, while others are insecticides, herbicides, or nemacides. The market for organic pesticides is growing as a result of more demanding consumers and more environmentally conscious farmers. This trend is further reinforced by the deregistration of several commercial pesticides that pose significant environment and health dangers to society.

The mustard project is in its second year of a three-year breeding program with elements of commercial demonstration on various levels to demonstrate proof of concept. There is a set of interrelated goals for the three-year program. We wanted to produce up to 20 varieties of mustard hybrids (fall and spring planted types) that show high levels of glucosinolate concentration in the meal (originally greater than 500 µmoles/g) and some species variation with respect to the types of glucosinolates present. In one year we have achieved that target and are raising the bar. Maximizing glucosinolates have not been maximized in meal before, and we believe we can make significant gains in this area in the next decade.

The species developed to date meet the goals of 25 to 40% oil content in the seed. The oil is 90% monosaturated or more in some cases. The oil is inedible and not suitable for high value industrial purposes. The yield goals of 2 tons per acre of seed appear to be readily achievable in rotation with dry land wheat production without irrigation. Some significant gains in yields are also highly likely over time. In rotation, wheat yields have increased as much as 20%. The mustard crop is planted and harvested with wheat equipment. The crop has a high biomass residue yield and a deep tap root, and the residues (including the roots) provide an alleopathic benefit to subsequent crops. Intercropping and double cropping may offer attractive pesticide reducing benefits. Mustard appears to be resistant to many of the pest common to canola and other brassicas.

Application trials of mustard meal show high levels of effectiveness with fungus, nematodes, cut worms, wire worms, crab grass and other agricultural pests. Mustard meal can be used directly on soils as a substitute for methyl bromide fumigation. Several varieties show excellent specialization potential.

We have met many of our three-year goals in one year. There has been a tremendous response from the agricultural and pesticide community and we believe there is a high likelihood of success. *...if ye have faith as a grain of mustard seed...nothing shall be impossible unto you.* ***(Matthew 17:20)***